RUSSIAN-CUBAN GNSS SERVICE FOR MONITORING AND ANALYSIS OF GEOPHYSICAL PARAMETERS

SERVICIO GNSS RUSO-CUBANO PARA MONITOREAR Y ANALIZAR PARÁMETROS GEOFÍSICOS

D. Marshalov[a†], O. Pons Rodríguez[b], Yu. Bondarenko[a], V. Suvorkin[a], I. Bezrukov[a] and S. Serzhanov[a]

a) Institute of Applied Astronomy of the Russian Academy of Sciences, St.-Petersburg, Russia; marshalov@iaaras.ru
b) Institute of Geophysics and Astronomy, Habana, Cuba
† corresponding author

Recibido 8/5/2020; Aceptado 21/5/2020

This article describes the process of creation of the Russian-Cuban global navigation satellite systems (GNSS) service for monitoring and analysis of geophysical parameters based on station with co-located space geodetic instruments. The station will be located at the site of the Institute of Geophysics and Astronomy of the Republic of Cuba in Havana and will be equipped to conduct high-precision GNSS and meteorological observations. The GNSS service will provide time series of station coordinates, Earth orientation parameters, local tectonic plate movements, tropospheric delays, ionosphere and meteorological parameters and will become the basis for further expansion of the Cuban regional geodetic network.

Este artículo describe el proceso de creación del sistema de satélites de navegación global (GNSS, por sus siglas en inglés) ruso-cubano, para monitorear y analizar parámetros geofísicos ubicado en una estación con instrumentos geodésicos spaciales co-localizados. La estación estará localizada en el Instituto de Geofísica y Astronomía de la Republica de Cuba en La Habana y estará equipada para realizar observaciones de alta precisión GNSS y meteorológicas. El servicio GNSS proveerá series temporales de las coordenadas de la estación, parámetros de orientaci'on de la Tierra, movimientos de placas tectónicas locales, retrasos troposféricos, parámetros de la ionosfera y meteorológicos, y se convertirá en la base para la futura expansi'on en Cuba de una red geodésica regional.

PACS: Geodetic techniques, *91.10.P-, 91.10.Pp; Geodetic reference systems, 91.10.Ws; Plate tectonics, plate motions, recent, *91.45.dk

I. INTRODUCTION

Currently, stations with co-located space-geodetic instruments (co-located stations) are actively created and developed in the world. A typical co-located station includes different instruments implementing the following space geodesy techniques:

- Very long baseline radio interferometry (VLBI);
- Global navigation satellite systems positioning (GNSS);
- Satellite/Lunar laser ranging (SLR/LRR);
- Doppler Orbitography and Radiopositioning Integrated by Satellite (DORIS).

The co-located station is also equipped with a time and frequency standard, data storage and transmission equipment, a weather station and engineering support facilities. Also, a local geodetic network is being created on the site of the co-located station for high-precision reference of instruments to the fundamental geodetic benchmark.

The time series of observations of a co-located station allows obtaining local geophysical parameters that can be used in the implementation of global reference systems. This will make it possible to analyze changes in sea level and ocean load models and increase the accuracy of the predicted Earth orientation parameters (EOP).

In 2019, the Institute of Applied Astronomy of the Russian Academy of Sciences (IAA) in cooperation with the Institute of Geophysics and Astronomy of the Republic of Cuba (IGA) began the construction of the Russian-Cuban co-located station in Cuba. The main objective of this project is to improve the accuracy of the Russian network of the co-located stations [1] through a significant improvement in geographical distribution. For the Republic of Cuba, the construction of this station will support the national reference frame at a modern high level of accuracy through joint processing of data from the stations of the Russian and global networks. Modelling of radio-interferometric observations considering the Russian-Cuban co-located station shows that the formal accuracy of Universal Time and EOP estimation can increase more than 2 times [2].

The GNSS service for monitoring and analysis of geophysical parameters will be organized based on the new Russian-Cuban co-located station. In order for the station to become a part of the international GNSS service (IGS), and the results of its observations could be used to solve space geodesy problems, it is necessary to ensure stable, compatible with each other determinations of station coordinates. To achieve these goals, the Russian-Cuban co-located station will be equipped to conduct high-precision GNSS and meteorological observations, as well as to implement all guidelines to the IGS sites [3].

II. STATION EQUIPMENT

The equipment of the Russian-Cuban co-located station can be divided into 7 main components:

1. Topcon CR-G3 GNSS antenna, which is designed to receive signals from global navigation satellite systems (GPS, GLONASS, Galileo).

2. The automatic weather station Vaisala WXT536 measures meteorological parameters such as temperature, relative humidity, wind speed and direction, atmospheric pressure and precipitation.

3. Floor cabinet with installed Supermicro server, Javad Delta-3T GNSS receiver, UPS unit, network switch, optical cross-connect, interface converter, secondary power supply, monitor and input devices. This component is responsible for the collection, storage and transmission of data from measuring instruments.

4. Fiber-optic cable, which is used for high-speed noise-protected data transmission from a GNSS service server to an Internet access point.

5. Hanging cabinet with mounted network switch, optical cross-connect and router receives and transmits data from the local network of GNSS service to the Internet.

6. Floor air conditioner, which is designed to maintain a constant temperature and humidity in the GNSS service room.

7. VoIP-phones and IP-camera, which are designed for communication with GNSS service operator and remote visual control of equipment.

The block diagram of the equipment of the Russian-Cuban co-located station is shown in Fig. 1, and photos of the equipment assembled in the laboratory are shown in Fig. 2 and Fig. 3.

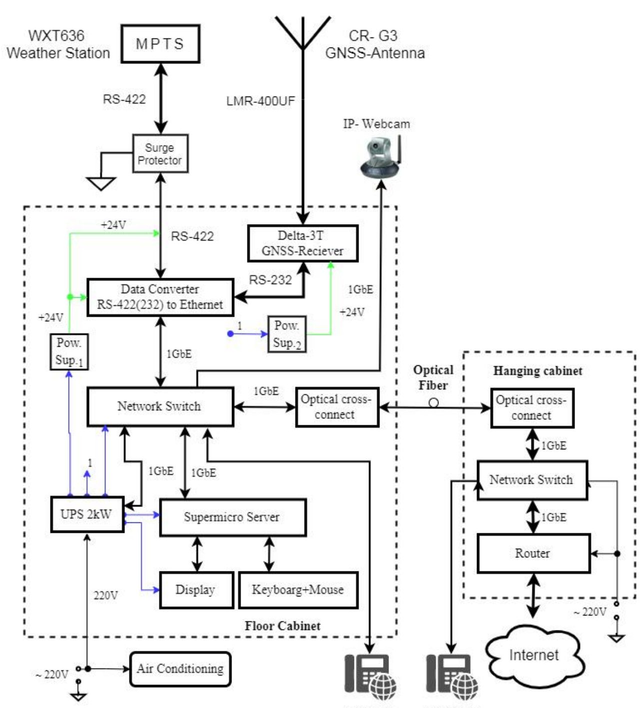

Figure 1. Block diagram of the equipment of the Russian-Cuban co-located station.

To configure and test the equipment, the operating system "Microsoft Windows 10", all the necessary device drivers and special software for controlling the GNSS receiver "Javad Net Hub" and the weather station "Vaisala Configugation Tool" were installed on the server. Communication between the weather station and the GNSS receiver is implemented via COM-ports using a special script written in the Python programming language. Storage and transfer of data to the IAA server is performed using the "Nexcloud" software.

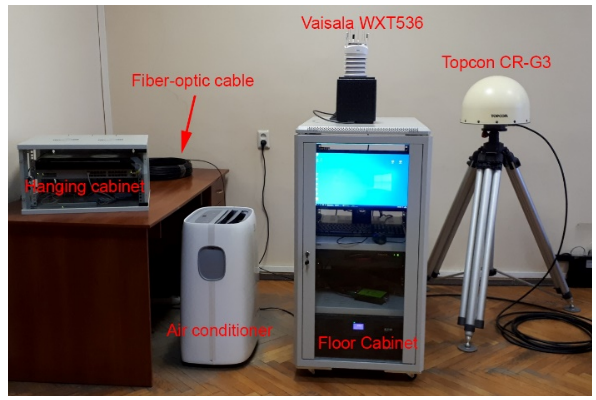

Figure 2. Laboratory assembly of equipment of the Russian-Cuban co-located station (general view).

Figure 3. Laboratory assembly of equipment of the Russian-Cuban co-located station (Floor cabinet).

III. STATION DESIGN

The Russian-Cuban co-located station will be located on the IGA site at Havana, La Lisa Municipality, 212. Fig. 4 shows a satellite image of the IGA site with the administrative building and the building where the GNSS service will be located. The site of the institute is guarded and has a fence around the entire perimeter.

The administrative building is connected to the electricity, water and Internet networks. The equipment for data receiving and transmission is supposed to be installed in a hanging cabinet in the administrative building. The equipment will be connected to the 220 V (60 Hz) electrical network and to the Internet through optical cross-connect and network controlled switch. A fiber-optic communication line is stretched from the administrative to the GNSS service building in a plastic pipe at a depth of 30-40 cm underground. The optical cable route is plotted in Fig. 4 with a dashed line.

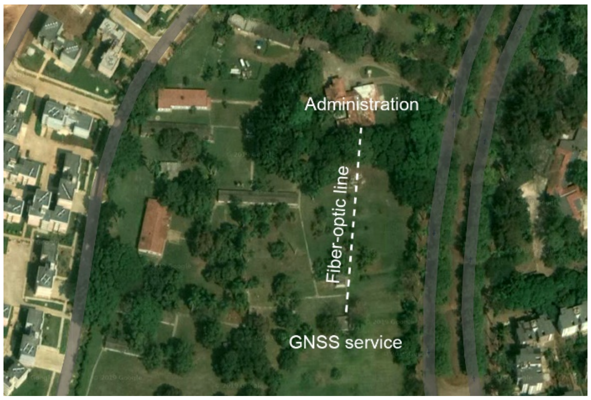

Figure 4. Satellite image of IGA site where the Russian-Cuban co-located station will be placed.

The GNSS service building is a monolithic reinforced concrete rectangular one-story building 3 meters high, 60 m^2 with a flat roof (Fig. 5). The building is connected to a 220 V (60 Hz) electrical network.

Figure 5. General view of the GNSS service building from the south side.

Fig. 6 shows the layout of the Topcon CR-G3 GNSS antenna and the Vaisala WXT536 weather station. The GNSS antenna is mounted on a platform at the top of the concrete pillar (figure 7), on the roof of the GNSS service building. The anchor point of the platform with coordinates 23.069163 N and -82.459731 E will become the main reference point of the GNSS service, as well as part of the local geodetic network. The antenna is connected by a coaxial cable to the GNSS receiver located in a floor cabinet in the GNSS service room. The automatic weather station is mounted on a metal mast 4.5 meters high, located 20 meters south of the GNSS service building, equipped with a lightning rod and surge protection device and connected by a multi-core signal cable to the interface converter located in a floor cabinet. Cables are laid along walls, roofs and underground in plastic tubes to protect against UV radiation, rain and mechanical damage.

A floor cabinet with equipment for collecting, storing and transmitting data from measuring instruments is located in the center of the GNSS service room and is connected to an electric socket by a power supply cable laid on the floor in a closed cable channel. The fiber-optic cable of the communication line, as well as signal cables from the weather station and GNSS antenna, are led to the floor cabinet in a closed cable channel. The air conditioner is connected to the vent hole by a sleeve for humid air outlet. The room will also have an IP-camera for remote visual control of equipment and a VoIP-phone for communication with the GNSS service operator.

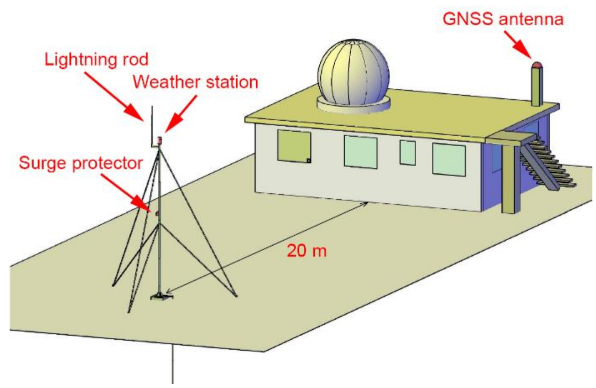

Figure 6. GNSS antenna and weather station layout.

Figure 7. Concrete pillar with a platform for a GNSS antenna mounting.

The installation of several different space-geodetic instruments on the site of the Russian-Cuban co-located station suggests the possibility of their high-precision reference to the fundamental geodetic benchmark. Works on creation of a local geodetic network were carried out to meet this requirement.

IV. PRACTICAL RESULTS

The processing of GNSS observations of the Russian-Cuban co-located station will be carried out by high-precision software developed in IAA. [4]. The physical models and algorithms implemented in this software meet the standards recommended by the International Earth Rotation Service (IERS) [5] and IGS [6]. The standard mode of operation is the processing of GNSS phase and pseudorange measurements of the globally distributed network on a daily intervals. GNSS observations of the Russian network of co-located stations are also included in the processing.

The following parameters are estimated for each day of observation:

1. EOP (polar motion and length of day);
2. Coordinates of stations in terrestrial reference frame;
3. Satellite motion parameters (daily initial coordinates and velocities, Solar radiation pressure model coefficients);
4. Satellites and receivers clock biases;
5. Intersystem (GPS-GLONASS) receiver bias;
6. Local zenith tropospheric delays;
7. Local atmospheric asymmetry gradients;
8. Local total electronic content in ionosphere;
9. Float phase ambiguities.

Thus, a series of parameters is compiled for the whole observation interval, giving practical results:

1. The normal matrices of station positions and EOP for obtaining terrestrial reference frame and tectonic movements;
2. EOP series;
3. Series of zenith tropospheric delays;
4. Series of total electronic content in ionosphere;
5. GLONASS satellites ephemeris.

V. CONCLUSIONS

At the current stage of creation of the Russian-Cuban GNSS service for monitoring and analysis of geophysical parameters, the equipment of the co-located station was assembled, adjusted and laboratory tested. At the IGA site the facilities for installation of the co-located station equipment were prepared and the local geodetic network was implemented. Design documentation for installation and connection of GNSS service equipment was developed at the IAA. Information on construction progress can be found on the IAA official website at http://iaaras.ru/en/dept/habana/.

VI. ACKNOWLEDGMENTS

This work was supported by the Ministry of Science and Higher Education of the Russian Federation (project no. RFMEFI61319X0094, agreement no. 075-15-2019-1717).

BIBLIOGRAPHY

[1] N. Shuygina, D. Ivanov, A. Ipatov, I. Gayazov, D. Marshalov et al., Geod. Geodyn. **10**, 150 (2019).

[2] D. V. Ivanov, M.-R. Uratsuka, A. V. Ipatov, D. A. Marshalov et al., Astrophys. Bull. **73**, 257 (2018).

[3] Current IGS Site Guidelines. https://kb.igs.org/hc/en-us/articles/202011433-Current- IGS-Site-Guidelines, 28/10/2019.

[4] V. Suvorkin, S. Kurdubov, I. Gayazov in Journées 2014 ”Systèmes de Référence Spatio-Temporels”, edited by Z. Malkin and N. Capitaine (Pulkovo observatory, St. Petersburg, 2014).

[5] IERS Conventions, edited by Gérard Petit and Brian Luzum. (Frankfurt am Main: Verlag des Bundesamts für Kartographie und Geodäsie, 2010), pp.179.

[6] IGS Analysis Center Coordinator. http://acc.igs.org/, 18/08/2019.